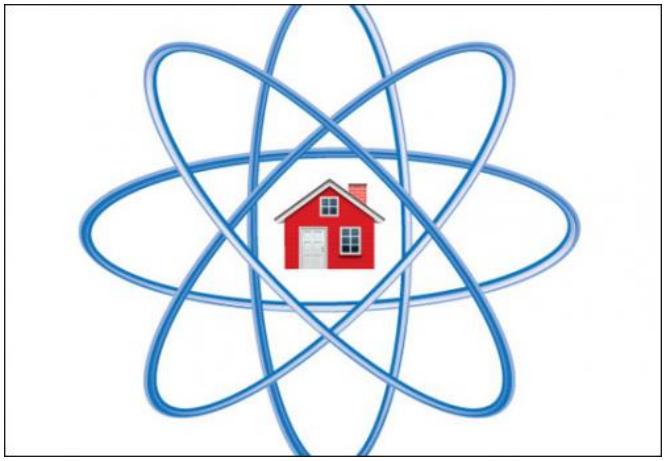
The nuclear reactor in your basement

19 February 2013, by Bob Silberg



How would you like to replace your water heater with a nuclear reactor? That's what Joseph Zawodny, a senior scientist at NASA's Langley Research Center, hopes to help bring about. It would tap the enormous power of the atom to provide hot water for your bath, warm air for your furnace system, and more than enough electricity to run your house and, of course, your electric car.

If your thoughts have raced to Fukushima or Three Mile Island or Chernobyl, let me reassure you. Zawodny is not suggesting that you put that kind of reactor in your house. What he has in mind is a generator that employs a process called Low-Energy Nuclear Reactions. (The same process is sometimes called Lattice Energy Nuclear Reactions. We'll just call it LENR.)

So what is LENR and how might it one day fill all your energy needs without risk of blowing up, melting down, or irradiating the neighbors?

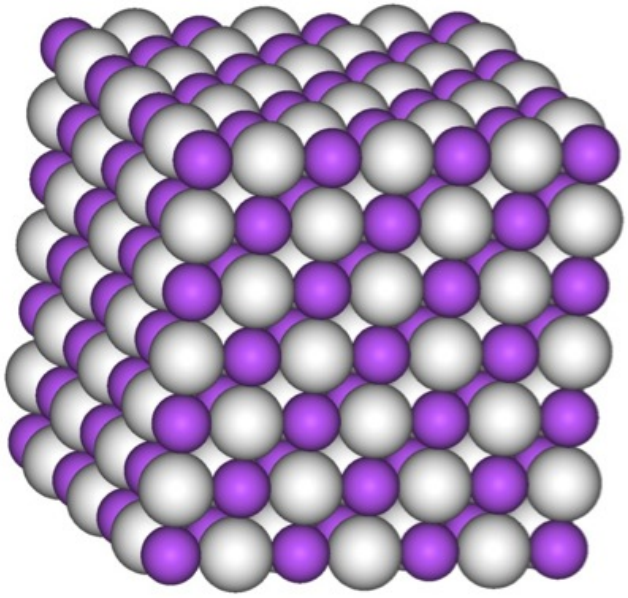
Nuclear energy in a nutshell

The nuclear generators which currently provide some of the world's electricity use a type of fission in which a very heavy nucleus (meaning one with lots of protons and neutrons) such as uranium breaks up into two or more lighter nuclei, releasing energy in the process.

The sun and all the other stars use nuclear fusion, in which two light nuclei (such as those of hydrogen) fuse together in an environment of very high temperature and pressure which overwhelms the mutual repulsion of their positive charges. Again, energy is released in the process—even more than in fission. We know how to use fusion in hydrogen bombs, but so far we lack the technology needed to harness it for more civilized purposes.

In the 1980s, two scientists named Stanley Pons and Martin Fleischmann announced that they had developed a "cold fusion" process that could create fusion through chemical means, without the high temperature or pressure of stars and bombs. There was no theory to explain how that could be possible, and other scientists were unable to reliably reproduce the experiments, so cold fusion lacked credibility for most physicists. Some scientists have continued working on this idea though, and they sometimes call it "LENR." But this process is not what Dr. Zawodny is exploring.

"There are a lot of people who are trying to just build something without understanding anything," Zawodny said. "It worked for Edison and the light bulb, but it took him a long time and that was a simple system. This is very complex. And if they make something that just barely works, and accidentally one in a thousand works really, really well, it's going to take down a house with their trial-and-error method."



In theory, a metal (gray) holding hydrogen ions (purple) as a sponge holds water (called a metal hydride) can provide one potential fuel for LENR.

"Several labs have blown up studying LENR and windows have melted," according to Dennis Bushnell, Langley's chief scientist, in an article he wrote for NASA's Future Innovation website. This, he wrote, indicates that "when the conditions are 'right' prodigious amounts of energy can be produced and released." But it's also an argument for the approach that the Langley researchers favor: master the theory first.

The epiphany

"For NASA Langley," according to Bushnell's article, "the epiphany moment on LENR was the publication of the Widom-Larsen Weak Interaction LENR Theory," which was published in 2006. According to Zawodny and Bushnell, this theory provides a better explanation than "cold fusion" for the results which researchers have obtained over the last couple of decades. And it might explain much more than that. At a meeting of the American Nuclear Society in November 2012, the theory's co-developer, Lewis Larsen, speculated that LENR may occur naturally in lightning—not only on present-day Earth, but also in the primordial cloud of gas and dust that became our solar system. If true, LENR might solve a mystery uncovered by NASA's Genesis mission, that the pattern of oxygen isotopes on the sun differs greatly from that of Earth.

The theoretical underpinnings of LENR are complex, but the basics are pretty easy to understand. Instead of splitting an atomic nucleus apart or ramming two mutually repelling nuclei together, Widom-Larsen's LENR simply offers a very slow-moving neutron to a nucleus. According to Zawodny, nuclei presented with sluggish neutrons slurp them up like a hungry Texan with a bowl of firehouse chili. But like many a chili consumer, the nuclei can find that their indulgence makes them, shall we say, unstable. And while I am too polite to continue the chili metaphor past this point, the nuclei do find that emissions relieve their distress.

With rare exception, Zawodny said, a nucleus which has lapped up one too many neutrons spits out an electron, which it gets by breaking up one of its neutrons into an electron and proton (and an anti-neutrino, but we can ignore that). So where it once had an extra neutron, making it an unstable isotope of whatever element it was, it now has an extra proton instead, which makes it a more stable isotope of a different element. This process releases energy which, hypothetically, can be used to generate electricity.

Concepts for an LENR-driven spaceplane developed by NASA and Spaceworks.

According to Zawodny, the challenge in making this work lies at the beginning of the process, generating those ultra-slow neutrons without expending more energy than the process yields. There are several hypothetical versions of the procedure, but here's a good example:

We start by processing nickel so that it can hold hydrogen the way a sponge holds water. The hydrogen is ionized, meaning that each hydrogen atom has its electron stripped away, leaving only a proton.

Electrons in the metal are made to oscillate together in such a way that the electromagnetic energy stored in tens of thousands of them is transferred to a relative few, giving them enough energy to merge with nearby protons (the hydrogen ions) and form slow-moving neutrons. Those neutrons, as we noted, are immediately captured by nuclei of the metal atoms, setting in motion a chain of events which turns the nickel into copper and releases useful energy.

The 1 percent solution

One percent of the nickel mined each year could meet the world's energy requirements at around a quarter of the cost of coal, according to estimates cited by Bushnell.

There are other interesting options as well, like turning carbon into harmless nitrogen, the main component of our atmosphere. "I don't know what could possibly be cleaner than that," Zawodny said. "You're not sequestering carbon, you're totally removing carbon from the system." In fact, this would be a great way to dispose of some toxic carbon compounds, such as those that were used in electrical transformers. "It's just a nasty sludge that everyone doesn't know what to do with," he said. "That's perfect fuel, in theory."

So what's the hitch? It's creating the right oscillation. "It turns out that the frequencies that we have to work at are in what I call a valley of inaccessibility," Zawodny said. "Between, say, 5 or 7 THz and 30 THz, we don't have any really good sources to make our own controlled frequency."

But solving that problem can wait until the theory is better understood. "From my perspective, this is still a physics experiment," Zawodny said. "I'm interested in understanding whether the phenomenon is real, what it's all about. Then the next step is to develop the rules for engineering. Once you have that, I'm going to let the engineers have all the fun."

And he is sure that if the Widom-Larsen theory is shown to be correct, resources to support the necessary technological breakthroughs will come flooding in. "All we really need is that one bit of irrefutable, reproducible proof that we have a system that works," Zawodny said. "As soon as you have that, everybody is going to throw their assets at it. And then I want to buy one of these things and put it in my house."

More information: More information about energy-related innovations at NASA and Caltech is available at climate.nasa.gov/EnergyInnovations/

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